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Request for grant of a patent

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The Patent Office

Cardiff Road
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1.	Your reference	P22609/LXM/RMC
2.	Patent application number *(The Patent Office will fill in this part)*	**9820064.5** 16 SEP 1998
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	The Court of Napier University Colinton Road EDINBURGH EH10 5DT
	Patents ADP number *(if you know it)*	7033803001
	If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4.	Title of the invention	"Energy Saving Displays"
5.	Name of your agent *(if you have one)*	Murgitroyd & Company
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	373 Scotland Street GLASGOW G5 8QA
	Patents ADP number *(if you know it)*	1198013
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country — Priority application number *(if you know it)* — Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application — Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	–
Description	8
Claim*(s)*	–
Abstract	–
Drawing*(s)*	3

10. If you are also filing any of the following, state how many against each item.

Priority documents	–
Translations of priority documents	–
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	–
Request for preliminary examination and search *(Patents Form 9/77)*	–
Request for substantive examination *(Patents Form 10/77)*	–
Any other documents *(please specify)*	–

11. I/We request the grant of a patent on the basis of this application.

Signature Murgitroyd & Company
MURGITROYD & COMPANY

Date 14/09/98

12. Name and daytime telephone number of person to contact in the United Kingdom — Roisin McNally 0141 307 8400

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DISPLAY TECHNOLOGY

Fluorescent dye doped polymers can be used to collect ambient light through the introduction of red, green and blue light emitting fluorescent dyes into the polymer host material. The colour of the emitted light can be changed into the required specification through variation of the dyes incorporated into the polymer. The principle of operation is shown in Figure 1. A transparent polymer film or sheet is chemically doped or blended with a fluorescent dye. The fluorescent dye should have a high quantum efficiency for converting natural light or indoor light into some visible colour. In principle, any fluorescent dye compatible with any transparent polymer can be used for this purpose. The contrast between the light power density emitted from the polymer and the light power density of the ambient light remains constant because this parameter is not effected by ambient light conditions as long as they are above a critical level and instead relies on the material parameters.

STATEMENT OF INVENTION

It is an object of this present invention to provide a transparent polymer film or sheet for use in illumination and display purposes.

According to the present invention there is provided a transparent polymer film or sheet which is doped or blended with a fluorescent dye for use in visual display wherein fluorescent light is generated when artificial ambient light, daylight or sunlight enters the dye doped polymer.

In general any fluorescent dye compatible with any

DISPLAYS

This invention relates to display technology.

FIELD

The present invention describes a method in which fluorescent dye doped polymers can be used to fabricate illuminated flat panel display elements from multiple applications such as road signs, advertisements, toys etc without the use of external electrical power.

HISTORY

In this field it is already known that flat panel display elements composed out of plastic polymers can be used as display elements.

Previous displays have the disadvantage that the sign is illuminated through the means of applying an external electrical power supply and converting this electrical power into light power and consequently this method consumes electrical power.

transparent polymer can be used for this purpose.

In a preferred embodiment of this invention the bottom surfaces and edges of the polymer film are covered with a highly reflective additional layer which acts as a mirror performing the role of total internal reflection of all light entering into the polymer.

Preferably the top surface of the polymer shall be covered with a dielectric stack mirror. In a preferred embodiment of this stack it is constituted of an alternating sequence of two dielectric films with alternately high and low refractive indices.

The composition of this dielectric stack is such that the aforementioned stack shall act as an interference filter to allow nearly 100% transmission of light from air into the polymer for wavelengths used for excitation of the dye. Further this aforementioned stack has nearly 100% reflection for light wavelengths emitted from the fluorescent dyes. The dielectric layers can be vacuum evaporated, spin coated or sputtered onto the surface of the polymer.

In an alternative preferred embodiment of this dielectric stack, thin films of two different polymers, with the two different refractive indices, can be applied to the polymer surface sequentially and vacuum pressed and/or thermally treated for each layer. This method has the advantage that it allows larger areas to be covered by the dielectric stack mirror.

Alternatively, cladding can also be used for the same purpose although the efficiency is not as good as with the dielectric stack mirror.

The present invention can be adapted for display purposes as the fluorescent light emitted from the dye can be coupled out from the polymer at the top surface by emitting or removing the dielectric stack mirror at a given surface area and by making an uneven or grated surface at the polymer air interface. The grating structure should be maximised for maximum diffraction for the emitted fluorescent light wavelength.

In an alternative preferred embodiment of the invention the replacement of the bottom mirror layer of the dielectric stack mirror, identical to the one applied to the top surface allows a combined reflective and transmissive mode of light collection and display operation.

Further an alternative preferred embodiment of the invention provides a further combination of dielectric stack and mirror combinations while using the principles previously described. In this embodiment the dielectric stack mirror is applied on both sides of the transparent polymer-dye matrix but no side mirrors are applied. Consequently the fluorescent light generated inside the polymer will be waveguided towards the edges of the polymer.

DESCRIPTION

As a first example of the invention Figure 1 describes the structure of the light emitting polymer in reflective mode. The transparent polymer is chemically doped or blended with a fluorescent dye. The fluorescent dye should have a high quantum efficiency for converting natural light or indoor light into some visible colour. The bottom surface and edges of the polymer are covered with a highly reflective additional

layer which acts as a mirror and ensures that all light entering through the top surface is fully reflected back into the polymer.

The top surface of the polymer is covered with a dielectric stack mirror which comprises two dielectric films with alternating high and low refractive indices. This dielectric stack serves as an interference filter allowing 100% transmission of light from the air to the polymer for the wavelengths used for excitation of the fluorescent dyes doped within the polymer. The dielectric stack however has a near 100% reflection for light wavelengths emitted from the fluorescent dyes doped within the polymer. The dielectric layers can be vacuum evaporated, spin coated or sputtered onto the surface of the polymer.

Alternatively, thin films of two different polymers with two different refractive indices can also be applied to the polymer surface sequentially vacuum pressed and/or thermally treated for each layer. This method allows larger areas to be covered by the dielectric stack mirror. Alternatively, cladding can also be applied for the same purpose although the efficiency is not as good as with dielectric stack mirror.

This arrangement, coupled with the fact that the polymer layer itself acts as a guide for light generated inside the polymer (polymer refractive index about 1.5, air refractive index about 1), ensures that the polymer layer acts as a "light-trap" for wavelengths used for excitation and light emission from the fluorescent dye embedded in the polymer matrix.

On the other hand the fluorescent light emitted from

the dye can be coupled out from the polymer at the top surface by emitting or removing the dielectric stack mirror at a given surface area and by making an uneven or grated surface at the polymer/air interface. The grating structure should be maximised for maximum diffraction for the emitted fluorescent light wavelength.

The intensity of the fluorescent light I1 ($mW/cm^2/nm$) emitted from the dye doped polymer (at a given dye concentration) at the grated surface is linearly proportional to the R1 at a given dye concentration;

$I1 \sim R1$ = total light collecting surface area (cm^2) / total grated area (cm^2)

This means that the larger ratio (R1) produces more fluorescent light. On the other hand, the contrast of the display defined as the intensity of the fluorescent light from the grated surface divided by the intensity of the ambient light is constant because this ratio is only dependent on the geometry of the display device (at a given dye concentration). This feature is particularly useful under variable ambient light conditions.

The device described above can be used to display letters, characters, symbols etc by using natural or artificial light from the environment and converting this light into a characteristic colour of fluorescent light and directing it (by total internal reflection or by interference) into the display area. By selecting the appropriate dye-polymer combination and by maximising the ratio of light collecting area divided by light emitting display area of a contrast of 10:1 or larger can be achieved for display purposes. This

contrast is independent from the ambient lighting conditions. It is emphasised again that this device does not consume any electrical power. However, the device will not provide enough light for the display purposes when the ambient light intensity decreases below a critical level. In this case a conventional light source can be switched on to provide light for excitation and consequently displaying information. This electrical source does not illuminate the display directly and works in an indirect fashion.

An alternative example of the invention is shown in Figure 2. By replacement of the bottom mirror layer with a dielectric stack mirror, identical to the one applied to the top surface, a combined reflective and transmissive mode of light collection and display operation is also possible. The principle of operation is shown in Figure 2. A combined reflective and transmissive mode of operation is particularly useful for displays fixed on the inside of shop windows. Again as in the reflective mode of operation, the contrast for displaying information is independent of ambient lighting conditions.

A third mode of operation is shown in Figure 3. A dielectric stack mirror is applied on both sides of the transparent polymer-dye matrix but no side mirrors are applied. Consequently the fluorescent light generated inside the polymer will be waveguided towards the edges. The value of fluorescent light intensity I2 ($mW/cm^2/nm$) at the edges is directly proportional to the R2;

$I2 \sim R2$ = total light collecting surface area (cm^2) / edge area (cm^2)

at a given concentration of fluorescent dye.

SUMMARY

In summary the devices described above can be used to display letters, characters, symbols etc by using natural or artificial light from the environment and converting this light into a characteristic colour of fluorescent light and directing it by total internal reflection or by interference into the display area. Through selection of the appropriate dye polymer combination and by maximising the ratio of light collecting area dividing by light emitting display a contrast of 10:1 or larger can be achieved for display purposes. This contrast being independent from ambient lighting conditions.

ADVANTAGES

The fluorescent light emitting polymer uses ambient light for excitation and therefore does not require external electrical power.

The optical power density from the fluorescent polymer is higher than the optical power of the ambient light. The ratio between these optical power densities does not depend on the ambient light conditions as long as they are sufficient for excitation of the fluorescent dye.

Figure 1

Structure of Light Emitting Polymer in reflective mode

G.Hayto
C.Hindle

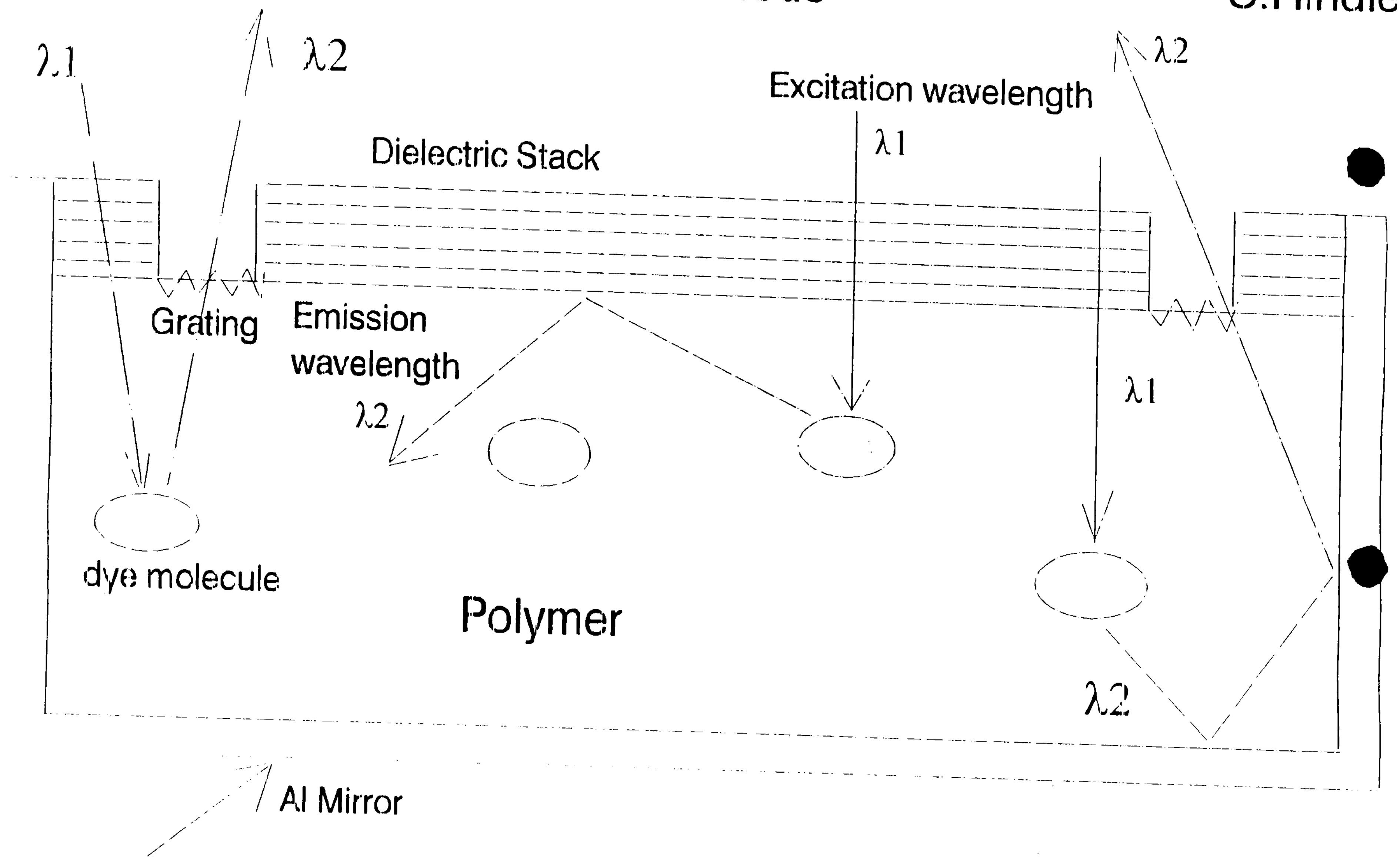


Figure 2

Structure of Light Emitting Polymer in combined reflective and transmissive mode

J.Hajto
C.Hindle

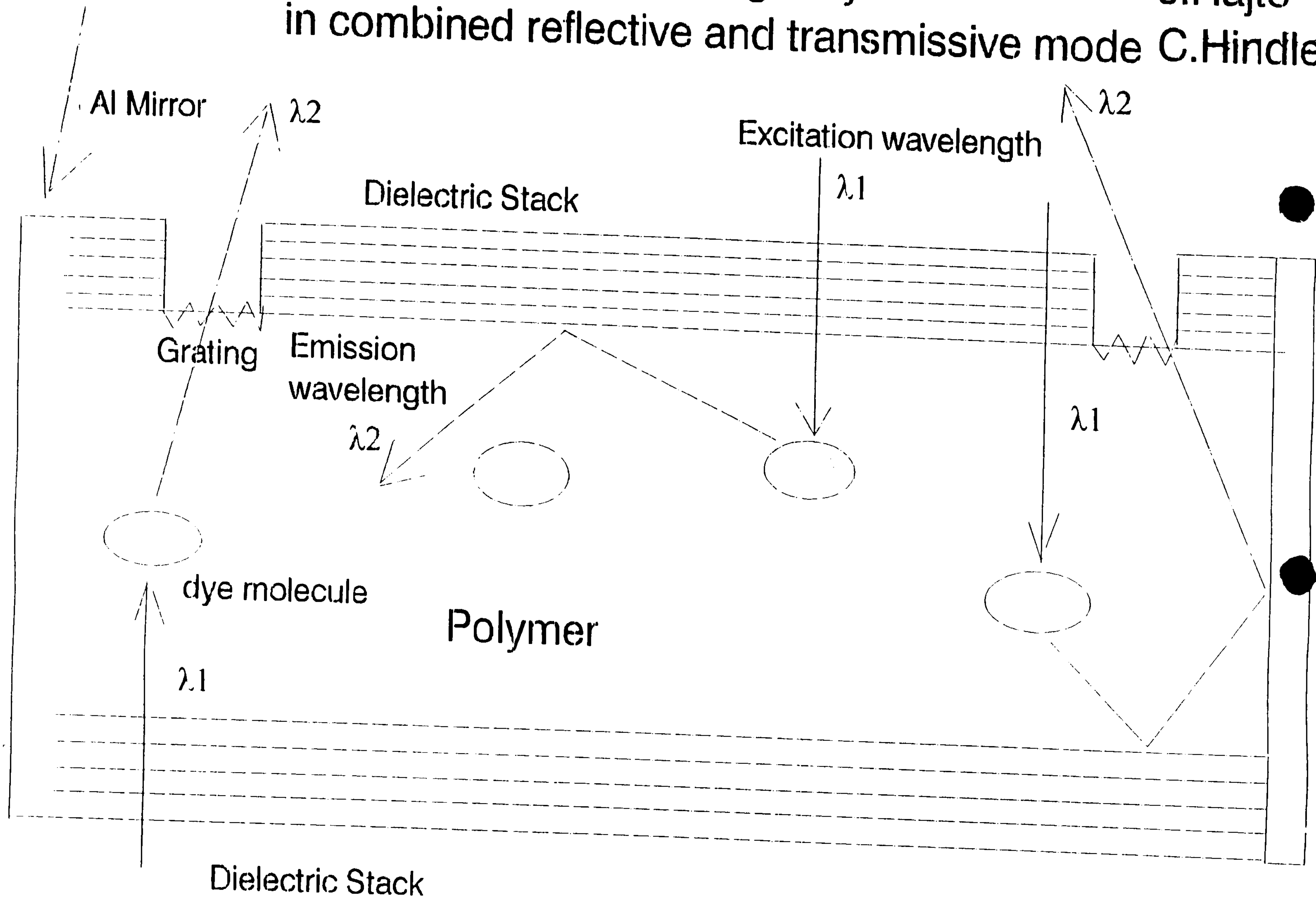
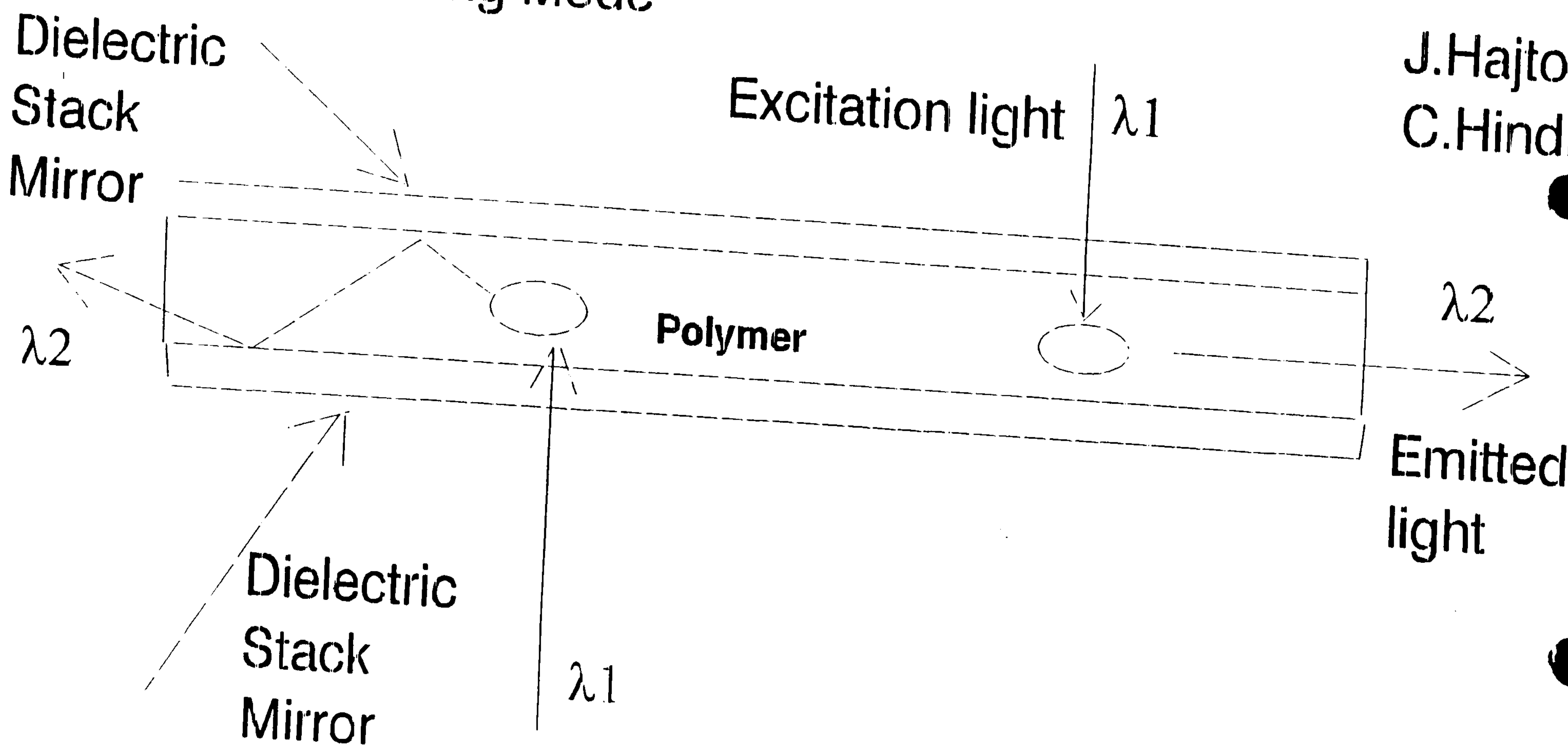


Figure 3

Structure of Light Emitting Polymer in the Edge Emitting Mode

J.Hajto
C.Hindle



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